Summary of Fish Inventories at Selected Road-Stream Crossings Assessed for Fish Passage Status, Monongahela National Forest, 2014

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Drive
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Report prepared by:
Colin Krause
March 2015

USDA Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Dr.
Blacksburg, VA 24060

Table of Contents

List of Figures

List of Tables

Introduction

Road-stream crossings have the potential to block or reduce fish passage and thus make populations or assemblages more vulnerable to extirpation. The passage status of many forest roads is unknown and National Forests across the U.S. are currently assessing fish passage at road-stream crossings in an effort to prioritize fish passage improvement projects.

Our primary objective was to inventory and assess aquatic organism passage (AOP) status and fish species presence at road-stream crossings on the Monongahela National Forest, WV. Our results will help prioritize passage improvement projects and will support application for grants to fund individual projects. Where passage improvement projects are implemented, we anticipate an increased likelihood of long-term fish population persistence.

Methods

Site Selection

The road-stream crossings surveyed for fish passage status, as well as the crossings additionally inventoried for fish species presence, were selected by Chad Landress, Monongahela National Forest, Fish Biologist (Figure 1).

Fish Inventory

At a subset of sites surveyed for fish passage status, we sampled the fish population to determine species presence. A crew of 7 technicians and 1-2 fish biologists sampled a stream reach length equal to 20 times the average bankfull channel width (with a 100 m minimum and 200 m maximum limit), both up and downstream of the crossing structure. Samples in each reach were collected by single-pass electrofishing with one DC backpack electrofishing unit. We recorded the identity (species) and number of all fish captured. Fish were then released live within the reach where they were captured. See Appendix A for detailed fish sampling methods and Appendix B for photos of the road-stream crossings sampled for fish.

AOP Inventory

Our methods are modified from the National Inventory and Assessment Procedure (Clarkin et al. 2005). We used a rod and level to determine elevations within the stream channel and crossing structure. We calculated crossing slope, outlet drop, perch, and slope x length to help characterize the crossing structure. These data were entered into a model to determine whether fish passage is impaired by the crossing structure. See Appendix C for detailed road-stream crossing survey methods, as well as refer to Coffman (2005) and Steele et al. (2007) for more detailed methodology.

Results

Fish Inventory

Average wetted stream width of the sample reaches ranged from 1.1-3.7 m (Table 1). Sample reach length ranged from 9-180 m at the downstream reaches and 100-194 m at the upstream reaches (Table 1). Downstream reach lengths <100 m are a result of private land or stream confluence with the mainstem. Depending on stream water conductivity and fish response, we set the backpack electrofisher from 150 to 450 volts DC (Table 1). Sampling time varied widely from 42 to 2,115 electrofishing seconds (Table 1).

We captured a total of 8 fish species, which include the following: Brook Trout, Rainbow Trout, Eastern Blacknose Dace, Western Blacknose Dace, Creek Chub, Mottled Sculpin, Blue Ridge Sculpin, and Banded Sculpin (Table 2). Brook Trout was the only species found at all 10 sample sites; the 2nd most prevalent species was Blue Ridge Sculpin, found at 6 of the sites (Table 2). For the majority of the species and crossings, individual fish species were found both downstream and upstream of the crossing structure, however there were occurrences where a species was only found either upstream or downstream (Table 2). Because the study objective is to assess species presence and the upstream and downstream sample efforts and areas were variable, caution is recommended if comparing fish quantities.

AOP Inventory

We visited a total of 36 road-stream crossings and surveyed 34; the two crossings not surveyed, a natural ford and a bridge, are passable to fish by design. Presented in this report are the AOP results for the 10 road-stream crossings that were also inventoried for fish species presence. Two of the crossings had more than one culvert; site WV03 had 2 pipes and WV15 had 3 pipes (Table 3). The crossing width (i.e. pipe width, or combined pipe width for multiple pipe crossings) was less than the upstream and downstream bankfull channel width at all 10 road-stream crossings inventoried for fish (the same is also true for all the crossings surveyed only for AOP) (Appendix D). Two of the crossings (WV12 and WV20) had continuous substrate throughout the length of the pipe, which makes a crossing passable by design. The rest of the crossings did not have continuous substrate and were not backwatered, therefore, outlet drop, pipe slope, and slope x length (a fish exhaustion factor) are used to assess passage status (i.e. passable, indeterminate, or impassable). For passage Filter A, which is for strong swimming and leaping fish such as Salmonids, the status was calculated as ‘passable’, ‘indeterminate’, or ‘impassable’ at 3, 4, and 3 sites respectively (Table 3). For passage Filter B, which is for moderate swimming and leaping fish such as adult minnows, the status was calculated as ‘passable’ or ‘impassable’ at 2 and 8 sites respectively (Table 3). For passage Filter C, which is for weak swimming and leaping fish such as darters and sculpins, the status was calculated as ‘passable’ or ‘impassable’ at 2 and 8 sites respectively (Table 3).

One of the sites, WV12 (Little Low Place) which had continuous substrate (the structure is an open bottom arch) has a small cement dam at the inlet, which when included in the survey changes the passage status of Filter B and C from passable to impassable (Table 3 and Appendix B). Overall, the majority of the 10 crossings were impassable or indeterminate for fish passage.

See Appendix D for detailed survey data and calculation results for the 34 road-stream crossings surveyed in summer 2014. Also provided separately to the Monongahela National Forest, is a database and GIS map product summarizing the AOP inventory results for the 36 sites. This database product stores all of the data collected at each site and the GIS product displays the location, site characteristics, and where applicable, the passage results for each road-stream crossing we visited. In addition, it contains hyperlinks to site photos for quick visual reference.

Fish Presence and AOP Passage Status

The majority of the crossings had fish present both upstream and downstream of the crossing regardless of AOP status (Table 4).

Within Filter A, there are 8 crossings that have fish up and downstream, 1 crossing with fish only upstream, and 1 crossing with fish only downstream. More specifically, there is 1 passable crossing with fish only upstream, 1 impassable crossing with fish only downstream, and the rest of the crossings have fish up and downstream regardless of passage status (Table 4).

Within Filter B, there are 8 crossings that have fish up and downstream, 1 crossing with fish only upstream, and 1 crossing with no fish up or downstream. More specifically, there is 1 impassable crossing with fish only upstream and the rest of the crossings have fish up and downstream regardless of passage status (Table 4).

Within Filter C, there are 5 crossings that have fish up and downstream, 2 crossings with fish only downstream, and 3 crossings with no fish up or downstream. More specifically, there is 1 passable crossing with fish only downstream, 1 impassable crossing with fish only downstream, and the rest of the crossings (which are impassable) have fish up and downstream (Table 4).

Discussion

All 10 sampled streams on the Monongahela National Forest represent coldwater fish habitat based on the fish species present. Brook Trout were present at all sites and sculpin species were present at 7 sites. By also assessing AOP status at these crossings, we gain additional insight into which crossings warrant replacement to improve fish passage and thus extend fish access to suitable habitat upstream.

Our AOP results show that road-stream crossings commonly prevent upstream fish passage; only 3 of the 10 crossings had a passable AOP status for adult trout (i.e. strong swimming and leaping fish; Filter A). Conditions are more dire for young-of-year (YOY) trout (moderate swimmers and leapers; Filter B), where only one crossing was passable (when dam at inlet of WV12 is accounted for) and the rest were impassable. Outlet drop triggered passage failure at 2 crossings for adult trout and 8 crossings for YOY trout; the other non-'passable' crossings were either indeterminate or impassable due to a potential exhaustion barrier (i.e. slope x length). When an exhaustion barrier is present, fish capable of leaping into the pipe face water velocities exceeding their swimming abilities or a combination of water velocity and pipe length that exhausts them before they can exit the upstream end of the structure. These conditions are created when crossing structures do not mimic natural channel characteristics such as bankfull channel width, slope, and substrate. Impassable crossing structures typically concentrate water into a steeper, narrower channel profile with less resistance to flow. The result is increased water velocity within the structure and scouring immediately downstream creating an outlet drop, or perch (Castro 2003). All the crossings structures surveyed were narrower than the natural bankfull channel. Undersized crossing structures disrupt natural stream processes such as transport of sediment and large wood, leading to blocked inlets or blowouts during storm events. Changes in stream flow and water velocities caused by undersized structures can lead to the development of passage barriers. Installation of undersized culverts may not immediately result in passage barriers, but over time the combined effect of varying flows and the unnatural characteristics/dimensions of the crossings can lead to the creation of barriers.

The AOP survey results indicate that the majority of the 10 fish sampled crossings have fish passage concerns. Yet the fish sampling shows that the majority of these crossings also have fish of the same species and Filter category both downstream and upstream of the crossing. At first glance this may appear as if fish are able to pass the crossing structure and access upstream habitat. However, it is important to recognize that an AOP rating of impassable does not necessarily mean a crossing is impassable 100% of the time. Very few crossings are actually completely impassable all the time under all flow conditions. Unless a study is conducted that is specifically designed to determine fish passage through the use of mark-recapture, radio frequency identification (RFID) tagging, or genetics methods, we cannot conclude passage status via a one-time presence/absence assessment (Roghair et al. 2014). By performing fish sampling and AOP surveys we can identify streams with species of interest (in this case Brook Trout) that also have passage concerns in order to prioritize for crossing replacement. Installation of a new passable crossing that mimics the natural channel will rejoin potentially isolated fish populations and extend the fish population's accessible habitat upstream.

When selecting crossings for replacement it is important to take the upstream habitat conditions and availability into account. For example, 3 (WV19, WV27, and WV41) of the 34 crossings surveyed for AOP had ≥3 m cascades and/or waterfalls visible just upstream. The replacement of a crossing with a natural barrier shortly upstream certainly limits the habitat extension of a replacement. The selection process to prioritize crossing replacement can be assisted with software designed specifically for this purpose, such as the Crossing Assessment Decision Support System (CADSS).

The results of our fish inventories and culvert surveys performed on the Monongahela National Forest in summer 2014 demonstrate the effects of road-stream crossings on aquatic organism passage. Any future inventories on the Forest will expand the baseline data necessary to further meet national and regional strategic goals, prioritize crossings for replacements, and compete for remediation funds.

Data Availability

Summer 2014 AOP and fish data reside in GIS and a MS Access database, which is managed by the CATT, and a copy has been provided to Chad Landress, Monongahela National Forest, Forest Fish Biologist. We will work with the Monongahela National Forest to develop custom queries and reports for the MS Access database, as needed.

Literature Cited

Castro, J. 2003. Geomorphic impacts of culvert replacement and removal: avoiding channel incision. US Fish and Wildlife Service Oregon State Office, Portland, OR.

Clarkin, K., A. Connor, M. J. Furniss, B. Gubernick, M. Love, K. Moynan, and S. W. Musser. 2005. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service, San Dimas Technology and Development Center, San Dimas, Ca.

Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through culverts. Master's Thesis, James Madison University. Harrisonburg, VA.

Roghair, C., C. Krause, and C. Dolloff. 2014. Assessment of mark-recapture and RFID approaches for monitoring fish passage on the Daniel Boone National Forest. Unpublished File Report. Blacksburg, VA: U.S. Department of Agriculture, Southern Research Station, Center for Aquatic Technology Transfer. 41 pp.

Steele, J., C. Kyger, C. Roghair and C. Dolloff. 2007. Fish passage status of road-stream crossings on selected National Forests in the Southern Region, 2007. Unpublished File Report. Blacksburg, VA: U.S. Department of Agriculture, Southern Research Station, Center for Aquatic Technology Transfer. 125 pp.

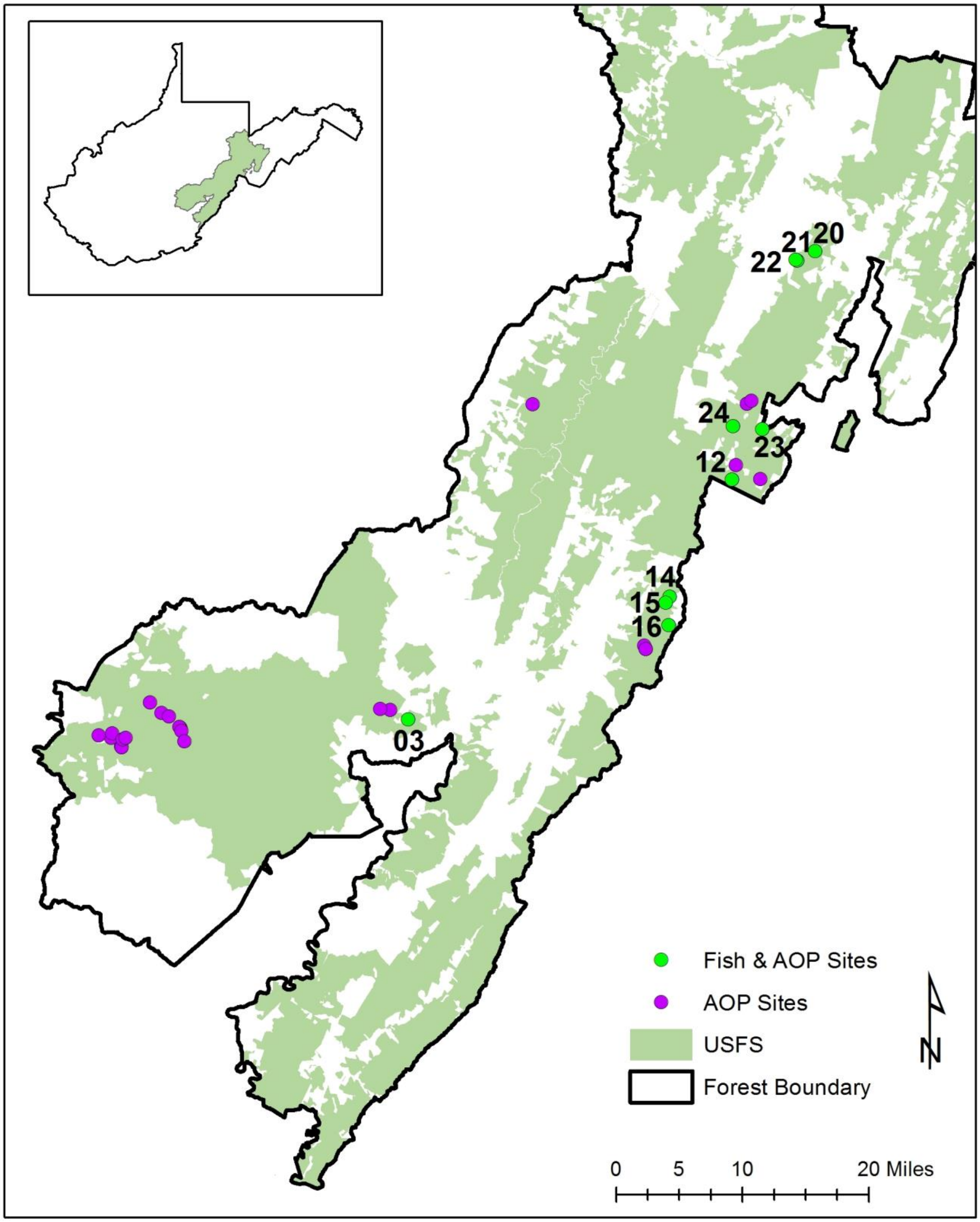


Figure 1. Road-stream crossings sampled for fish and/or surveyed for fish passage status, Monongahela National Forest, West Virginia.

Table 1. Electrofishing reach size sampled up and downstream of road-stream crossings and electrofisher settings and shock time. Fish sampling occurred June 24, 25, and 26th 2014 with a crew of 7 technicians and 1-2 fish biologists.

			Downstream Efish Reach					Upstream Efish Reach				
Watershed	Crossing ID	Stream Name	Avg. Wetted Width (m)	Bankfull Channel Width (m)	Reach Length (m)	Efish Settings	Efish Seconds	Avg. Wetted Width (m)	Bankfull Channel Width (m)	Reach Length (m)	Efish Settings	Efish Seconds
Big Run												
	WV12	Little Low Place	3.3	4.8	100	300 dc	691	2.2	5.0	100	400 dc	702
	WV23	Back Run	2.1	7.7	154	200 dc	942	3.5	6.7	134	250 dc	1,193
	WV24	Elk Run	1.7	4.7	100	400 dc	904	1.4	4.9	100	350 dc	703
Elk River												
	WV03	Unnamed Trib. to Crooked Fork	1.2	9.0	97*	300 dc	768	1.9	7.0	140	200 dc	832
North Fork of Deer Creek												
	WV14	Unnamed Trib. to N. Fk. of Deer Cr.	2.0	7.4	9*	350 dc	113	2.9	4.6	100	450 dc	215
	WV15	North Fork of Deer Creek	3.6	9.0	180	500 dc	2,018	5.1	9.7	194	350 dc	2,115
	WV16	Elleber Run	2.7	4.2	100	500 dc	1,067	1.1	2.6	100	450 dc	782
Seneca Creek												
	WV20	Lower Gulf Run	3.7	4.9	63*	300 dc	349	3.0	5.5	110	250 dc	411
	WV21	Whites Run	2.5	4.9	100	200 dc	706	2.1	6.2	124	200 dc	464
	WV22	Smith Run	3.0	4.6	15*	150 dc	42	1.5	3.7	100	250 dc	148

*Downstream reach length was less than 20 bankfull widths or the 100 m minimum due to either private property or a stream confluence

Table 2. Fish species and number of individuals captured up and downstream of sampled road-stream crossings (note that up and downstream sample efforts and areas were not equal, thus, caution is recommended if comparing quantities).

			Filter A (Strong Swimmers)				Filter B (Moderate Swimmers)								Filter C (Weak Swimmers)					
			Oncorhynchus mykiss (Rainbow Trout)		Salvelinus fontinalis (Brook Trout)		Salvelinus fontinalis YOY (Brook Trout YOY)		Rhinichthys atratulus (Eastern Blacknose Dace)		Rhinichthys obtusus (Western Blacknose Dace)		Semotilus atromaculatus (Creek Chub)		Cottus bairdii (Mottled Sculpin)		Cottus caeruleomentum (Blue Ridge Sculpin)		Cottus carolinae (Banded Sculpin)	
Watershed	Crossing ID	Stream Name	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U
Big Run																				
	WV12	Little Low Place	-	-	22	22	13	29	-	-	-	-	-	-	-	-	-	-	-	-
	WV23	Back Run	-	-	37	35	13	45	-	-	-	-	-	-	-	-	25	39	-	-
	WV24	Elk Run	-	-	30	13	8	12	-	-	-	-	-	-	-	-	12	13	-	-
Elk River																				
	WV03	Unnamed Trib. to Crooked Fork	-	-	0	1	-	-	-	-	76	77	13	40	38	2	-	-	-	-
North Fork of Deer Creek																				
	WV14	Unnamed Trib. to N. Fk. of Deer Cr.	-	-	2	6	0	2	-	-	-	-	-	-	-	-	1	0	-	-
	WV15	North Fork of Deer Creek	-	-	74	52	95	87	-	-	-	-	-	-	15	16	44	23	14	28
	WV16	Elleber Run	-	-	39	28	34	25	-	-	-	-	-	-	23	5	9	8	17	2
Seneca Creek																				
	WV20	Lower Gulf Run	3	1	5	6	0	1	2	0	-	-	-	-	-	-	1	0	-	-
	WV21	Whites Run	-	-	42	43	7	5	-	-	-	-	-	-	-	-	-	-	-	-
	WV22	Smith Run	-	-	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Summary of AOP survey attributes and results for the road-stream crossings that were sampled for fish.

Watershed	Crossing ID	Stream Name	Pipe	Road Num.	Junction Road	Milepost (mi)	Latitude	Longitude	Pipe Shape	Continuous Substrate
Big Run										
	WV12	Little Low Place	1 of 1	FS60	FS106	3.4	N38.59083	W79.61801	Open bottom arch	Yes
	WV23	Back Run	1 of 1	FS814	Sawmill Run Rd.	1.5	N38.64806	W79.57177	Circular	No
	WV24	Elk Run	1 of 1	FS922	FS112	1.6	N38.65161	W79.61521	Circular	No
Elk River										
	WV03	Unnamed Trib. to	1 of 2	831	219	0.2	N38.32002	W80.09511	Box	No
		Crooked Fork	2 of 2	831	219	0.2	N38.32002	W80.09511	Box	No
North Fork of Deer Creek										
	WV14	Unnamed Trib. to N. Fk. of Deer Cr.	1 of 1	FS1681	250	1.4	N38.45750	W79.71139	Circular	No
	WV15	North Fork of Deer	1 of 3	1681	250	2.1	N38.45021	W79.71682	Box	No
		Creek	2 of 3	1681	250	2.1	N38.45021	W79.71682	Box	No
			3 of 3	1681	250	2.1	N38.45021	W79.71682	Box	No
	WV16	Elleber Run	1 of 1	1681	250	4.3	N38.42467	W79.71345	Pipe arch	No
Seneca Creek										
	WV20	Lower Gulf Run	1 of 1	33/3	29	5.5	N38.85090	W79.49039	Circular	Yes
	WV21	Whites Run	1 of 1	33/3	29	3.4	N38.84045	W79.51700	Pipe arch	No
	WV22	Smith Run	1 of 1	33/3	29	3.3	N38.84190	W79.51908	Circular	No

Table 3 Continued. Summary of AOP survey attributes and results for the road-stream crossings that were sampled for fish.

Watershed	Crossing ID	Stream Name	Pipe	Back-watered	Outlet Drop (ft)	Slope (%)	Pipe Length (ft)	Slope x Length	Filter A	Filter B	Filter C
Big Run											
	WV12	Little Low Place*	1 of 1	No	0.6	7	49	335	Passable	Passable	Passable
	WV23	Back Run	1 of 1	No	1.9	4	40	163	Indeterminate	Impassable	Impassable
	WV24	Elk Run	1 of 1	No	3.7	2	33	59	Impassable	Impassable	Impassable
Elk River											
	WV03	Unnamed Trib. to Crooked Fork	1 of 2	No	1.5	2	17	28	Passable	Impassable	Impassable
			2 of 2	No	1.5	1	17	25			
North Fork of Deer Creek											
	WV14	Unnamed Trib. to N. Fk. of Deer Cr.	1 of 1	No	1.3	7	38	273	Impassable	Impassable	Impassable
	WV15	North Fork of Deer Creek	1 of 3	No	0.7	6	22	138	Indeterminate	Impassable	Impassable
			2 of 3	No	0.7	6	22	134			
			3 of 3	No	0.7	6	22	136			
	WV16	Elleber Run	1 of 1	No	1.4	3	41	133	Indeterminate	Impassable	Impassable
Seneca Creek											
	WV20	Lower Gulf Run	1 of 1	No	0.6	3	30	96	Passable	Passable	Passable
	WV21	Whites Run	1 of 1	No	1.8	3	31	81	Indeterminate	Impassable	Impassable
	WV22	Smith Run	1 of 1	No	2.5	6	47	286	Impassable	Impassable	Impassable

*Survey results shown for Little Low Place exclude a small cement dam at the inlet of the open bottom arch, which when included in the survey changes the passage status of Filter B and C to from passable to impassable.

Table 4. Fish passage result (i.e. passable, intermediate, or impassable) and the presence (✓) or absence (✗) of fish upstream (U) and downstream (D) for Filter A (strong swimmers), Filter B (moderate swimmers), and Filter C (weak swimmers).

			Filter A			Filter B			Filter C		
				Fish Captured			Fish Captured			Fish Captured	
Watershed	Crossing ID	Stream Name	Result	D	U	Result	D	U	Result	D	U
Big Run											
	WV12	Little Low Place	Passable	✓	✓	Passable*	✓	✓	Passable*	✗	✗
	WV23	Back Run	Indeterminate	✓	✓	Impassable	✓	✓	Impassable	✓	✓
	WV24	Elk Run	Impassable	✓	✓	Impassable	✓	✓	Impassable	✓	✓
Elk River											
	WV03	Unnamed Trib. to Crooked Fork	Passable	✗	✓	Impassable	✓	✓	Impassable	✓	✓
North Fork of Deer Creek											
	WV14	Unnamed Trib. to N. Fk. of Deer Cr.	Impassable	✓	✓	Impassable	✗	✓	Impassable	✓	✗
	WV15	North Fork of Deer Creek	Indeterminate	✓	✓	Impassable	✓	✓	Impassable	✓	✓
	WV16	Elleber Run	Indeterminate	✓	✓	Impassable	✓	✓	Impassable	✓	✓
Seneca Creek											
	WV20	Lower Gulf Run	Passable	✓	✓	Passable	✓	✓	Passable	✓	✗
	WV21	Whites Run	Indeterminate	✓	✓	Impassable	✓	✓	Impassable	✗	✗
	WV22	Smith Run	Impassable	✓	✗	Impassable	✗	✗	Impassable	✗	✗

*Survey results shown for Little Low Place exclude a small cement dam at the inlet of the open bottom arch, which when included in the survey changes the passage status of Filter B and C to from passable to impassable.

Appendix A: Field Methods for Fish Inventory

Fish Inventory Methods:

1. Measure bankfull width (m) in a straight riffle outside the influence of the road/stream crossing both up and downstream of the crossing

2. Electrofish 20 bankfull widths upstream and 20 downstream, with a 100m min and 200m max cap:
    a. Upstream of culvert
        - Electrofish bankfull width x 20
        - Minimum reach length 100 m
        - Maximum reach length 200 m
    b. Downstream of culvert
        - Electrofish bankfull width x 20
        - Minimum reach length 100 m
        - Maximum reach length 200 m

3. Identify fish to species and record total count of fish per species; for trout, count adults and young-of-year separately

4. Record:
    - crossing ID
    - stream name
    - date
    - crew
    - average wetted width (m)
    - bankfull width (m)
    - reach length (m)
    - up or downstream of crossing
    - shocker settings
    - shock time
    - comments

Appendix B: Photos of Road-Stream Crossings Inventoried for Fish

Sites in Big Run Watershed

WV12 Inlet, Little Low Place

WV12 Outlet, Little Low Place

WV12 Dam at inlet of open bottom arch

WV23 Inlet, Back Run

WV23 Outlet, Back Run

Sites in Big Run Watershed continued

WV24 Inlet, Elk Run

WV24 Outlet, Elk Run

Site in Elk River Watershed

WV03 Inlet, UT to Crooked Fk.

WV03 Outlet, UT to Crooked Fk.

Sites in North Fork of Deer Creek Watershed

WV14 Inlet, UT to N. Fk. of Deer Cr.

WV14 Outlet, UT to N. Fk. of Deer Cr.

WV15 Inlet, N. Fk. of Deer Cr.

WV15 Outlet, N. Fk. of Deer Cr.

WV16 Inlet, Elleber Run

WV16 Outlet, Elleber Run

Sites in Seneca Creek Watershed

WV20 Inlet, Lower Gulf Run

WV20 Outlet, Lower Gulf Run

WV21 Inlet, Whites Run

WV21 Outlet, Whites Run

WV22 Inlet, Smith Run

WV22 Outlet, Smith Run

Appendix C: Field Methods for AOP Inventory

Modified Culvert Inventory and Assessment Protocol

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Ramble Rd.
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Manual prepared by:
Sara Sweeten, Colin Krause, and Craig Roghair
February 2011
(revised July 2012, June 2014)

Purpose

This culvert inventory and assessment method is a modified version of the National Inventory and Assessment Procedure (NIAP; Clarkin et al 2003) developed to collect data needed to run coarse filter evaluations of fish passage (Coffman 2005)

References:

Clarkin, K., A. Connor, M. J. Furniss, B. Gubernick, M. Love, K. Moynan, and S. W. Musser. 2003. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service, San Dimas Technology and Development Center, San Dimas, Ca.

Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through culverts. Master's Thesis, James Madison University, Harrisonburg, VA

Harrelson, Cheryl C; Rawlins, C. L.; Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Safety Protocols

- *All survey crew members must wear a safety vest and hardhat when performing surveys*
- *Felt bottom shoes are required for all survey crew members, regardless of what job you are assigned*
- *Know the hazards in and around the stream channel (slick rocks, snakes, glass, etc.)*
- *Be aware of cars, ditches, and other road hazards; set out slow cones at each survey site*
- *Hold weekly 'tailgate safety' meetings to discuss and remind crew of hazards*

Field Survey, Six Steps:

1. Navigate to site
2. Classify the crossing type
3. Record crossing attributes
4. Survey longitudinal profile and check results
5. Draw site sketch
6. Take and document photos

1. Navigate to Site

Using maps and/or GPS, navigate to the road/stream crossing.

On route to the site, record the **junction road** and **milepost** using the vehicle trip meter. Do not estimate these numbers from maps or GPS/GIS.

For each site record:

A. <u>Stream Name</u>
   - *as shown on USGS 1:24,000 data*

B. <u>Road Name</u>

C. <u>Land Ownership</u>
   - *FS, state, private, other*

D. <u>Crew Members</u>
   - *full names of all crew*

E. <u>Junction Road</u>
   - *road that connects with the stream crossing road*

F. <u>Milepost</u>
   - *distance from junction road to crossing; example 0.2 mi*

G. <u>Quad Name</u>
   - *as shown on USGS 1:24,000 data*

H. <u>Date</u>

2. Classify the Crossing Type

All sites must be classified as one of the following:

A. <u>Natural Ford</u>

B. <u>Bridge</u>

C. <u>No Access</u>

D. <u>Insufficient Upstream Habitat</u>

E. <u>Does not exist</u>

F. <u>Surveyed</u>

- *If site is classified as A-E, stop here*
- *Otherwise proceed to steps 3-6*

2A-F. Crossing Type

A. <u>Natural Ford</u> = no structure present and natural substrate throughout entire crossing

B. <u>Bridge</u> = structure spans over stream and natural substrate is present throughout entire crossing

C. <u>No Access</u> = cannot get to site due to private property, road too busy to safely survey site, etc; must make note in comments with reason for no access

D. <u>Insufficient Upstream Habitat</u> = habitat upstream of crossing unable to support aquatic life

E. <u>Does Not Exist</u> = crossing shown on map or GPS due to a road and stream intersecting, but in the real world they do not intersect, thus there is no crossing

2A-F continued. Crossing Type

F. <u>Surveyed</u> = complete steps 3-6 if the crossing is a pipe (circular or arch), box, ford, or vented ford with suitable fish habitat

3. Record Crossing Attributes

A. Flow Condition
   a. Wet (continuous flow)
   b. Isolated pools (discontinuous flow)
   c. Dry (no flow)

B. Pipe Shape
   a. Open Bottom Arch
      - *no longitudinal survey; but record pipe height and width*
   b. Circular
   c. Box
   d. Pipe Arch
   e. Ford
   f. Vented Ford

C. Pipe Material
   a. Corrugated Metal
   b. Concrete
   c. Plastic
   d. Smooth Metal
   e. Wood
   f. Unknown

D. Pipe Measurements
   a. Pipe Width (ft); example 5.2 ft
   b. Pipe Height (ft)

E. Continuous Substrate (yes/no)

3A. Flow Condition

a. <u>Wet</u> = continuous flow

b. <u>Isolated pools</u> = discontinuous flow

c. <u>Dry</u> = no flow

3B. Pipe Shape

a. Open Bottomed Arch = no structure material on channel bottom and natural substrate present throughout entire crossing; considered passable on all filters; *(no longitudinal survey, but record height and width measurements)*

b. Circular = height and width of pipe are equal

c. Box = square or rectangular shaped

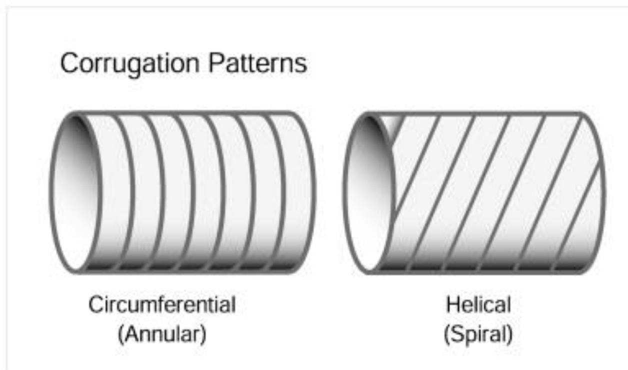
d. Pipe Arch = similar to circular pipe but height and width are not equal

3B continued. Pipe Shape

e. Ford = can be constructed in various manners including slated (often concrete or wooden), paved, or any method that alters the natural substrate

f. Vented Ford = ford surface with any pipe or culvert underneath; each pipe and the ford itself must be surveyed

3C. Pipe Material



a. Corrugated Metal = can have helical or concentric corrugations; may or may not have rust line, may be made a single piece or multiple plates bolted together

b. Concrete = used in many box and some circular and arch culverts

3C continued. Pipe Material

c. Plastic = made of plastic (PVC or HDPE), may or may not have corrugations

d. Smooth Metal = metal pipe with no corrugations

e. Wood = wood and logs are used to make log stringers, log box culverts, and circular culverts

f. Other = an unknown material or one not listed above; make a note in the comments field about the pipe material

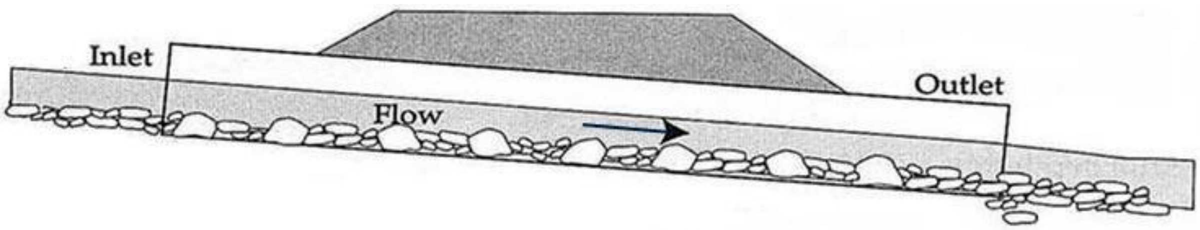
3D. Pipe Measurements

a & b. Pipe Width and Height (ft) = the inside height and width of each pipe is measured using a stadia rod or tape measure; measure at the widest and highest point of the pipe; dig down through substrate to pipe if necessary

3E. Continuous Substrate

D. Continuous Substrate = each pipe needs to be checked for continuous substrate; the substrate must fully run the length of the culvert, be wide enough to provide a natural substrate for fish; and be representative of the stream bed

Note: if pipe is full of gravel to the point where it is somewhat plugged (i.e. blocking flow & restricting fish passage) it is NOT considered continuous substrate; in this case make a note in the comments



4. Survey Longitudinal Profile and Check Results

Survey the following points:

A. BM
   - bench mark; using marking paint, mark a spot that will not move during the course of the survey and has a good view of the stream corridor

B. P2
   - edge of culvert or ford inlet

C. P3
   - road surface near middle of culvert; mark spot with marking paint that will not move during the course of the survey

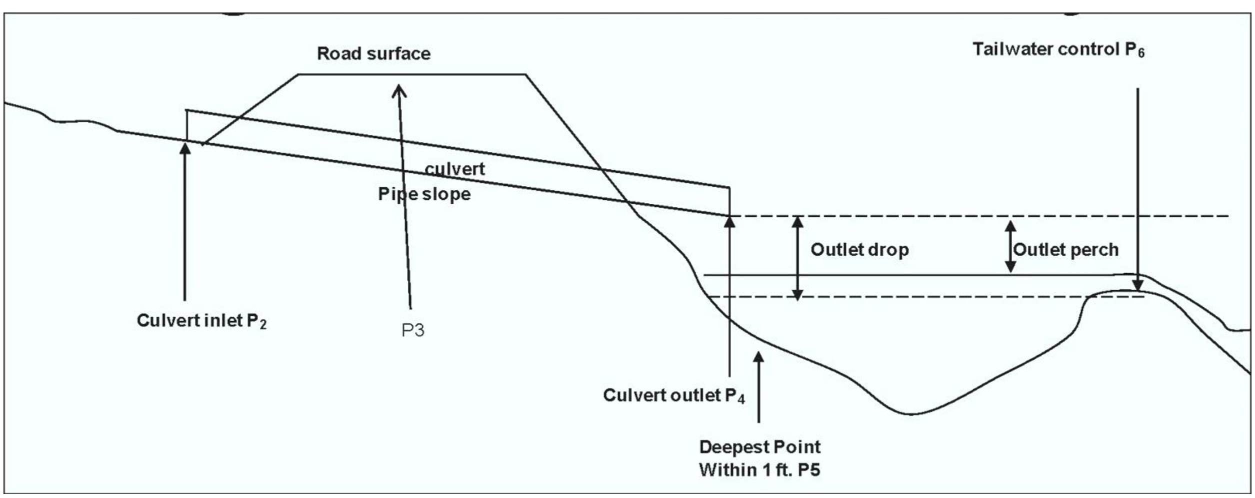
D. P4
   - edge of culvert or ford outlet

E. P4b
   - edge of outlet apron, when present place stadia rod at the lowest point on the apron

F. P5
   - deepest point within one foot of P4, or within one foot of P4b if an apron is present

G. P6
   - tailwater control; take elevation measurement from average lowest spot in the hydraulic control between outlet pool and riffle

Note: If P2 and/or P4 are embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P2 and P4 elevations from top of substrate; no need to dig down.



4. Longitudinal Survey Points

A. <u>Bench Mark</u> (BM) = initial reference (or starting) point of the survey, mark with paint and place stadia rod on a point that will not move during the survey; examples of locations to mark: road surface, a rock, guardrail, top of the culvert

B. <u>Culvert Inlet</u> (P2) = used for determining culvert slope; if inlet is embedded place stadia rod on top of substrate, otherwise place on corrugation of pipe

Note: If P2 is embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P2 elevation from top of substrate; no need to dig down.

B2. <u>Ford Inlet</u> (P2) = used for determining ford slope; place stadia rod on upstream edge of ford at deepest location

C. <u>Road Surface</u> (P3) = used to determine head-water depth for flood capacity as well as road-fill volume calculations; mark with paint and place stadia rod near middle of road close to center of culvert on a spot that will not move during the course of the survey; if working on a wetted ford and can't use marking paint, mark P3 with a rock by scrapping algae away or on unique spot on ford

4 continued. Longitudinal Survey Points

D. <u>Culvert Outlet</u> (P4) = used to determine culvert slope and outlet perch; if outlet is embedded place stadia rod on top of substrate, otherwise place on corrugation of pipe

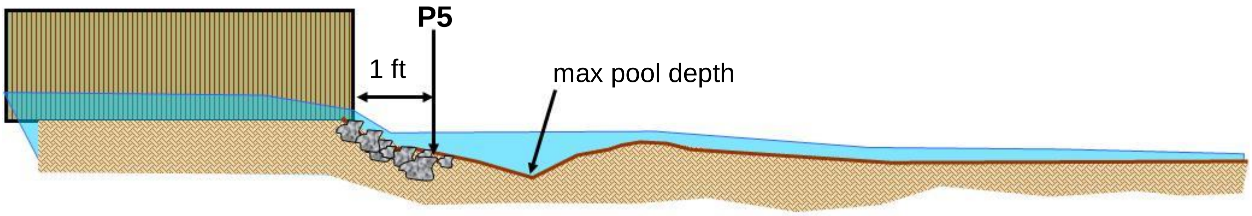
Note: If P4 is embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P4 elevation from top of substrate; no need to dig down.

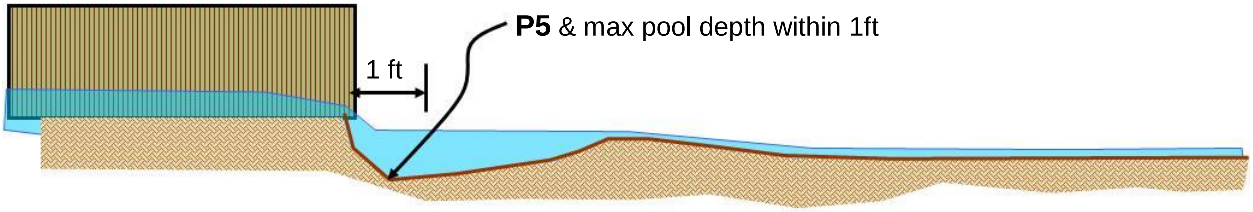
D2. <u>Ford Outlet</u> (P4) = used to determine ford slope and outlet perch; place stadia rod on downstream edge of ford

4 continued. Longitudinal Survey Points

E. Outlet Apron (P4b) = a hardened surface (often concrete) at the pipe outlet intended to dissipate scouring; not every pipe has an outlet apron; when present place the stadia rod on the average lowest point of the downstream edge of the apron to take an elevation reading

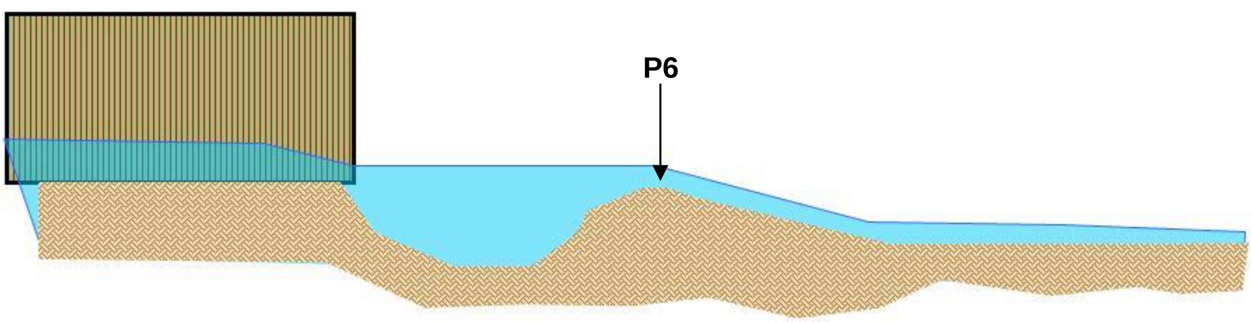
F. Deepest Point within 1ft (P5) = place stadia rod at the lowest streambed elevation within the leaping distance of the fish species (1 ft); if an apron is present place stadia rod within 1 ft of P4b





4 continued. Longitudinal Survey Points

G. Tailwater Control (P6) = used to determine perch, residual inlet depth, and residual pool depth; P6 is the hydraulic control between outlet pool and riffle; if there is no outlet pool then there is no tailwater control; when present place stadia rod at the lowest average elevation of the stream bottom



Survey Set-Up Instructions

1. Using marking paint, mark the bench mark and P3 on surfaces that will not move during the survey
2. Run measuring tape from just above P2 to below P6; it is preferable to run the tape through the pipe, however if not possible then tape can be run on road surface
3. Set up level in a safe spot where all the points are visible and where the level will not have to be moved during the survey
4. Shoot elevations and stations of all points
5. Check that results seem correct by comparing calculated values to what you visually observe at the crossing (if not, redo survey); calculate backwatered, outlet drop, and pipe slope

    A. Backwatered Calculations
    1. BM Rod Read + 100 = Height of Instrument (HI)
    2. HI – P6 Rod Read = P6 Elevation
    3. HI – P2 Rod Read = P2 Elevation
    4. P6 Elevation – P2 Elevation = Positive or Negative Value
        - *Positive = Backwatered*
        - *Negative = Not Backwatered*

    B. Outlet Drop Calculations (only when P6 present)
    1. HI – P4 Rod Read = P4 Elevation
    2. P4 elevation – P6 elevation = Positive or Negative Value
        - *Positive = Height (ft) Fish Must Jump to Enter Pipe*
        - *Negative = No Outlet Drop Present*

    C. Perch Calculations (only when P6 absent)
    1. Hi – P5 Rod Read = P5 Elevation
    2. P5 Elevation + Water Depth at P5 = Water Surface (WS)
    3. P4 Elevation – WS = Perch

    D. Pipe Slope Calculations
    1. P2 Elevation – P4 Elevation = Rise
    2. P4 Station – P2 Station = Length
    3. Rise / Length = Slope
    4. Slope X Length = Slope X Length

6. **Repeat for each pipe**; don’t forget to repeat for ford surface on vented fords
7. Move level to change its elevation for the closing procedure
8. Shoot to bench mark and P3

9. Check that survey closes (within ±0.02 inches); follow the ‘survey close calculations’ below

Survey Close Calculations

1. BM Rod Read + 100 = Height of Instrument (HI)
2. HI - P3 Rod Read = Known Elevation for P3
3. Move Level
4. New P3 Rod Read
5. New P3 Rod Read + Known Elevation for P3 = New HI
6. New BM Rod Read
7. New HI - New BM Rod Read = New Elevation
8. 100 - New Elevation = Error (must be within ±0.02)

10. If survey does not close or results don’t make sense, the survey must be repeated

Notes for multiple pipe, dry stream, and no outlet pool scenarios:

Multiple Pipes

- Pipes are counted from left to right when looking downstream
- All information for steps 3 and 4 must be collected for each pipe
- Check results for each pipe before closing survey
- It is possible for multiple pipes to have an individual P6 for each pipe; however, often all pipes will share one outlet pool and therefore have the same P6

Dry Streams

- Dry streams are surveyed in the same manner as streams with water
- Record water depth at P5 = 0
- Make note in comments that stream is dry

No Outlet Pool

- If there is no outlet pool, there will be no P6
- Make note in comments that P6 is not present

No Outlet Pool and a Dry Stream

- If there is no outlet pool, there will no P6
- If stream is dry record water depth at P5 = 0
- Make note in comments that stream is dry and P6 not present

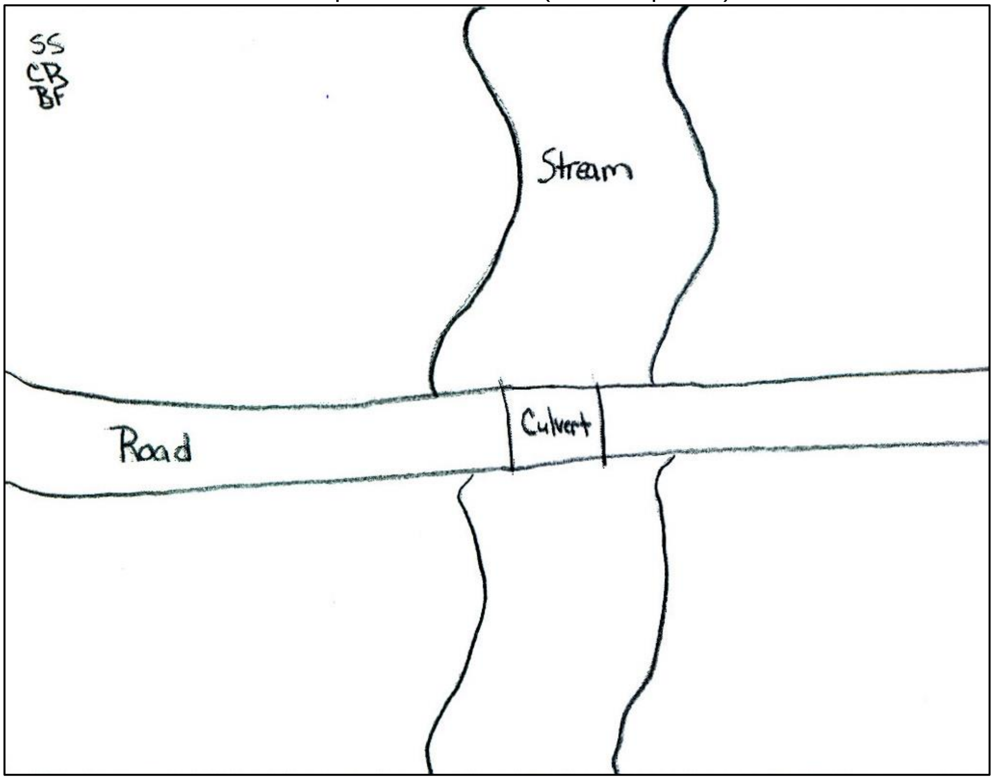
5. Draw Site Sketch

The site sketch must include:

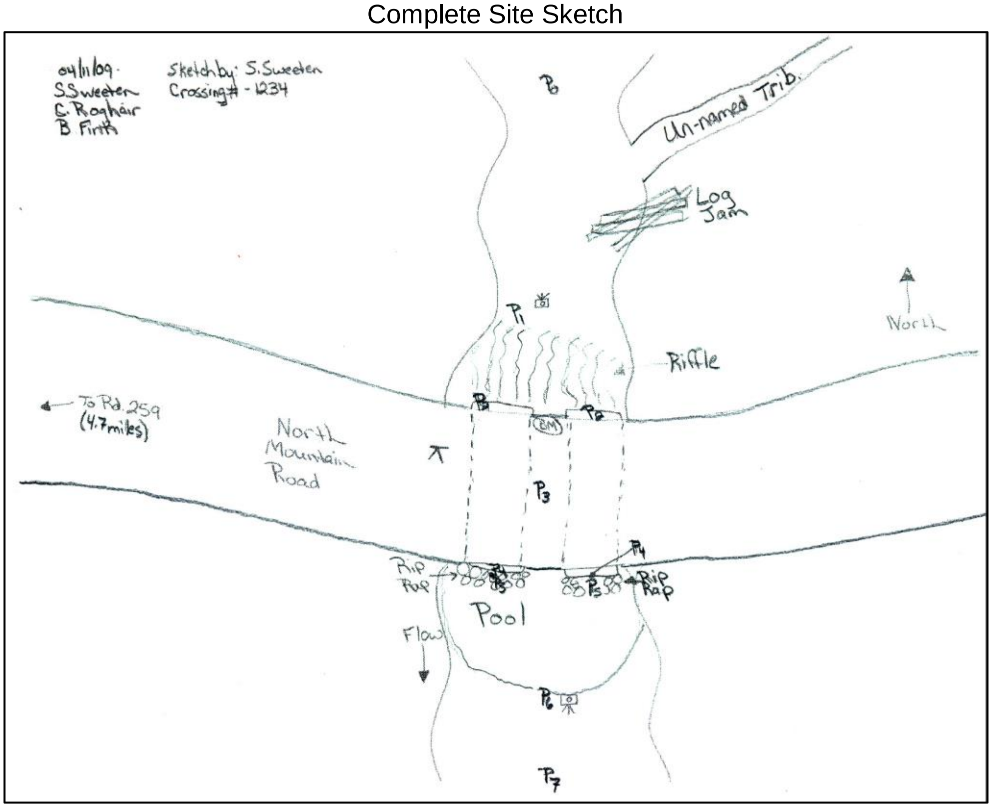
A. Crew members (full names)
B. Date
C. Crossing ID
D. Note person who drew sketch
E. North arrow
F. Direction of flow
G. Road name
H. Junction road name
I. Milepost
J. Stream name
K. Photo locations
L. Location of P points
M. Location of benchmark
N. Location of level
O. Pipe number for multiple pipes (pipe 1 on left looking downstream)
P. Outlet apron
Q. Debris jams
R. Depositional bars
S. Tributaries (include name if named)
T. Features unique to site (buildings, landmarks, etc.)
U. Damages/obstacles inside structure
V. Location of riprap or bank armoring
W. Any additional comments

5. Site Sketch

Incomplete Site Sketch (not acceptable)



Complete Site Sketch



6. Take and Document Photos

Photo Requirements:

Take a photo of the whole inlet and outlet at each site. Try to include all pipes in photos if possible. Also photograph any unique features of the site.

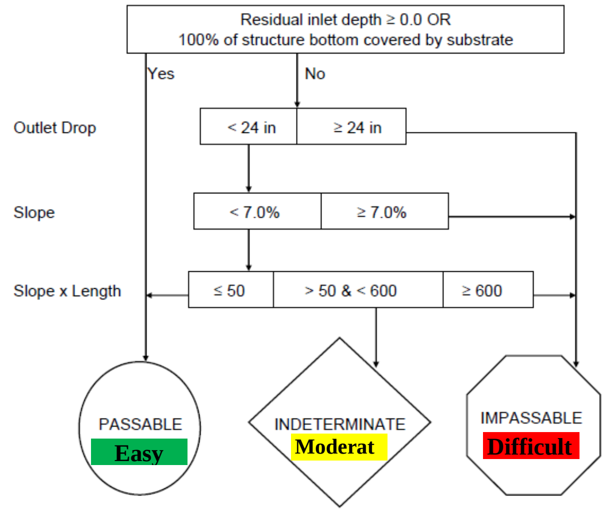
A. Stadia rod, crew member, and whiteboard must be in each photo
B. Identify site with proper site ID on whiteboard
C. All pipes should be visible
D. Channel should be included
E. Get as much of the crossing and stream in the photo as possible
F. Whiteboard should be upright, legible, and clear in photo
G. Make sure there is no glare on whiteboard
H. Check each photo before moving to next site
I. Record the photo identifier numbers for images taken

Common Photo Problems:

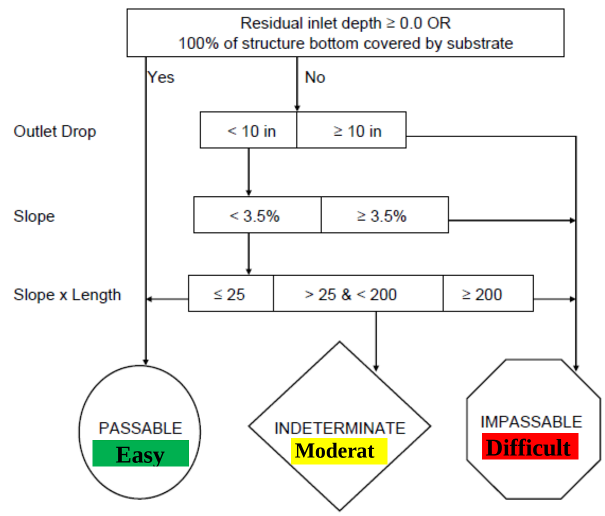
- Blurriness
- Zoomed in too far
- Zoomed out too far
- Cannot see whiteboard
- Stadia rod not included
- Cannot see all the pipes
- Light reflecting off the whiteboard
- Incorrectly labeled whiteboard

Coffman Models

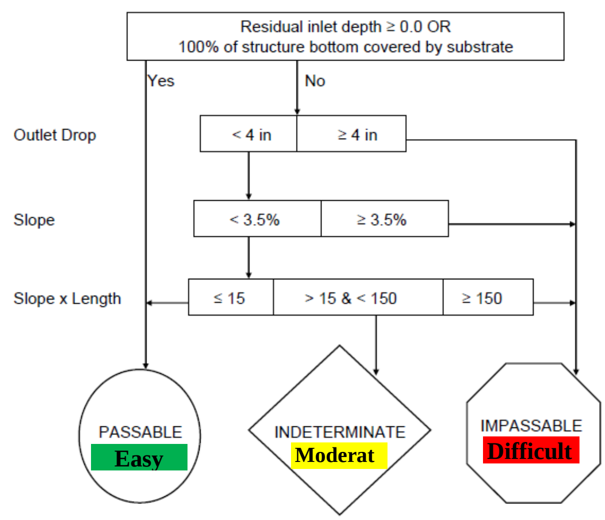
Filter A
Application: strong swimmers and leapers
Example: adult brook trout



Filter B
Application: moderate swimmers and leapers
Examples: adult minnows, age-0 brook trout



Filter C
Application: weak swimmers and leapers
Examples: darters, sculpins



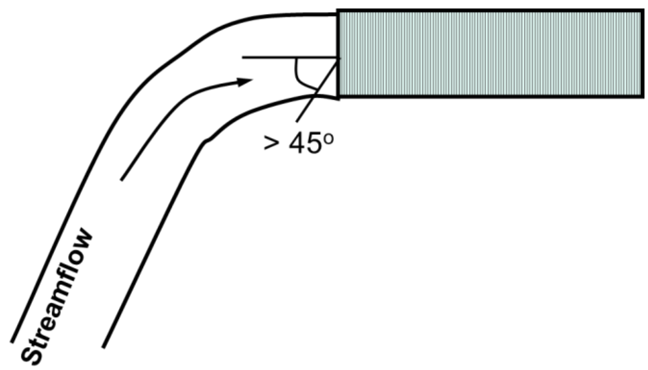
Source: Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through culverts. Master's Thesis, James Madison University. Harrisonburg, VA. Bold color is our interpretation of status.

Addendum: Additional Attributes Collected for 2014 WV AOP

Fill Eroding = deteriorating road fill that is unstable or slumping

In crossing comments field, note location of erosion; e.g. inlet eroding, outlet eroding, road surface eroding, etc.

Poor Alignment = whether or not the structure is poorly aligned with stream channel



Substrate Up/Downstream = the most prevalent substrate present within the bankfull channel

1	Organic Matter		dead leaves/plants
2	Clay	<2 mm	sticky
3	Silt	<2 mm	slippery
4	Sand	Silt-2 mm	grainy
5	Small Gravel	3-16 mm	sand-thumbnail
6	Large Gravel	17-64 mm	thumbnail-fist
7	Cobble	65-256 mm	fist-head
8	Boulder	>256 mm	>head
9	Bedrock		solid rock

Bankfull Channel Width Up/Downstream = the channel width that contains bankfull discharge; measured in a straight riffle outside of the influence of the road crossing

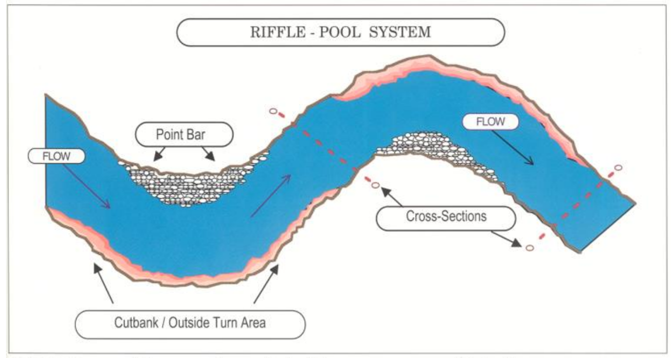
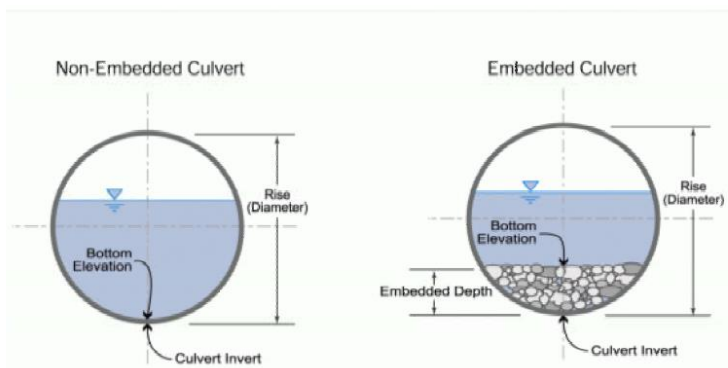


FIGURE 21. Recommended cross-section locations for bankfull stage measurements in "riffle/pool" systems.

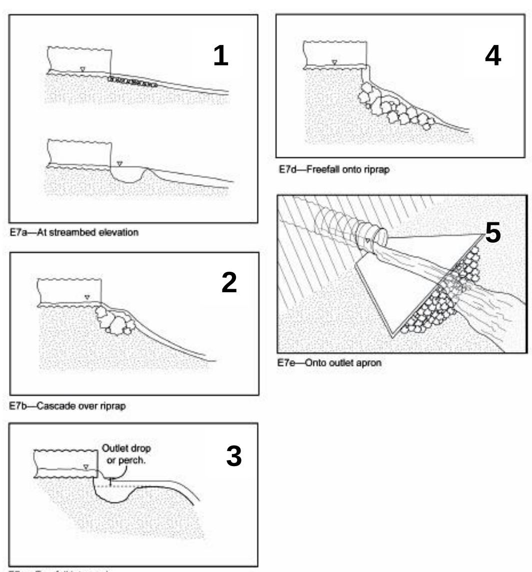
Pipe Condition = whether pipe is in good, fair, or poor condition; this is a judgment call by the crew

Pipe Embedded = bottom of pipe is below elevation of stream channel



Outlet Type =

1. At stream grade
2. Cascade over riprap
3. Freefall into pool
4. Freefall onto riprap
5. Outlet Apron



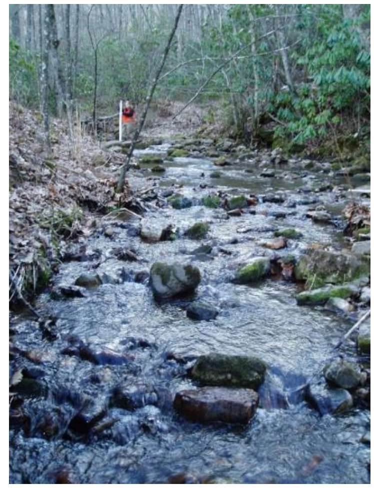
Pipe Broken = breaks in pipe or rusted through

Inlet Blocked & Percent Blocked = whether or not inlet of pipe is blocked with debris and the percentage that the inlet that is blocked

Inlet Bent = whether or not the inlet of the pipe is bent

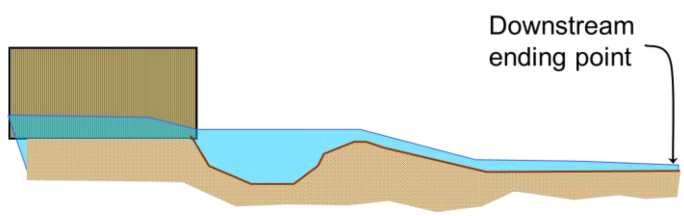
Water Under Pipe = whether or not water is flowing completely or partially under the pipe rather than through it due to a undermined or rusted through pipe

P0 = point upstream of the culvert inlet used to capture upstream channel gradient; located in riffle as far upstream as viewable with level



P1 = inlet gradient control point; also referred to as the tailwater control of the first resting pool; located upstream of the inlet at the beginning of a riffle

P7 = point downstream of the culvert outlet used to capture upstream channel gradient; located in a riffle as far downstream as viewable with level



Appendix D: AOP Survey Data

Table A (Appendix C). The table on the following 5 pages contains the AOP survey data collected at 34 road-stream crossings on the Monongahela National Forest in June 2014.

[1] Survey results shown for WV12, Little Low Place exclude a small cement dam at the inlet of the open bottom arch, which when included in the survey changes the passage status of Filter B and C to from passable to impassable.
[2] Natural substrate (i.e. bedrock or boulder) acting as an apron.
[3] Perch is used when P6 is absent.

Crossing ID	Stream Name	Pipe #	Road #	Junction Rd.	Mile-post	Latitude	Longitude	Pipe Shape	Structure Material	Outlet Type	Stream Flow
WV01	UT to Crooked Fork	1	251	219	1.7	N38.33112	W80.12110	Circular	Corrugated metal	Outlet apron[2]	Wet continuous
WV02	Crooked Fork	1	251	219	2.7	N38.33232	W80.13573	Pipe arch	Corrugated metal	Free fall into pool	Wet continuous
WV03	UT to Crooked Fork	1	831	219	0.2	N38.32002	W80.09511	Box	Concrete	Free fall onto riprap	Wet continuous
		2	831	219	0.2	N38.32002	W80.09511	Box	Concrete	Free fall onto riprap	Wet continuous
WV04	UT to Big Run #1	1	FS917	FS112	0.9	N38.67726	W79.59391	Circular	Corrugated metal	Freefall into pool	Isolated pools
WV05	UT to Big Run #2	1	917	112	2.0	N38.68072	W79.58766	Pipe arch	Corrugated metal	Free fall into pool	Wet continuous
WV06	Teeter Camp Run	1	48	28	0.0	N38.60733	W79.61148	Circular	Corrugated metal	Free fall into pool	Wet continuous
WV07	UT to Sams Run	1	48E	48	0.4	N38.59068	W79.57597	Circular	Corrugated metal	Outlet apron	Wet continuous
WV12	Little Low Place[1]	1	FS60	FS106	3.4	N38.59083	W79.61801	Open bottom arch	Corrugated metal	At stream grade	Wet continuous
WV14	UT to N. Fk. of Deer Cr.	1	FS1681	Rt250	1.4	N38.45750	W79.71139	Circular	Corrugated metal	Cascade over riprap	Wet continuous
WV15	North Fork of Deer Cr.	1	1681	250	2.1	N38.45021	W79.71682	Box	Wood	Free fall into pool	Wet continuous
		2	1681	250	2.1	N38.45021	W79.71682	Box	Wood	Free fall into pool	Wet continuous
		3	1681	250	2.1	N38.45021	W79.71682	Box	Wood	Free fall into pool	Wet continuous
WV16	Elleber Run	1	1681	Rt250	4.3	N38.42467	W79.71345	Pipe arch	Corrugated metal	Free fall onto riprap	Wet continuous
WV17	Sutton Run	1	1678B	1678	0.1	N38.39726	W79.74712	Circular	Corrugated metal	Free fall onto riprap	Wet continuous
WV18	UT to Sutton Run	1	1678B	1678	0.3	N38.40145	W79.74937	Circular	Corrugated metal	Free fall onto riprap	Wet continuous
WV19	UT to Sutton Run	1	FS1678	North Fk. Rd.	2.6	N38.39737	W79.74744	Circular	Corrugated metal	At stream grade	Wet continuous
WV20	Lower Gulf Run	1	33/3	29	5.5	N38.85090	W79.49039	Circular	Corrugated metal	At stream grade	Wet continuous
WV21	Whites Run	1	33/3	29	3.4	N38.84045	W79.51700	Pipe arch	Concrete	Free fall into pool	Wet continuous
WV22	Smith Run	1	33/3	29	3.3	N38.84190	W79.51908	Circular	Corrugated metal	Free fall into pool	Wet continuous
WV23	Back Run	1	FS814	Sawmill Run	1.5	N38.64806	W79.57177	Circular	Corregated metal	Freefall onto riprap	Wet continuous
WV24	Elk Run	1	FS922	FS112	1.6	N38.65161	W79.61521	Circular	Corrugated metal	Freefall onto riprap	Wet continuous
WV25	McGee Run	1	765	1560	0.6	N38.68040	W79.90773	Circular	Corrugated metal	Cascade over riprap	Wet continuous
WV27	UT to Cranberry River	1	Rd. off 752	76	0.1	N38.29182	W80.51397	Pipe arch	Corrugated metal	Cascade over riprap	Wet continuous
WV28	UT to Cranberry River	1	752	76	1.5	N38.29072	W80.51314	Pipe arch	Corrugated metal	Outlet apron[2]	Wet continuous
WV30	UT to Cranberry River	1	CR7/6	81	0.0	N38.30118	W80.52820	Circular	Corrugated metal	Free fall into pool	Wet continuous
		2	CR7/6	81	0.0	N38.30118	W80.52820	Circular	Corrugated metal	Free fall into pool	Wet continuous
WV31	Hinkle Branch	1	CR7/6	81	1.5	N38.30411	W80.54615	Circular	Corrugated metal	Freefall onto riprap	Wet continuous
		2	CR7/6	81	1.5	N38.30411	W80.54615	Circular	Corrugated metal	Free fall into pool	Wet continuous
WV32	UT to Cranberry River	1	81	76	1.0	N38.30630	W80.52639	Pipe arch	Corrugated metal	Cascade over riprap	Wet continuous
WV33	UT to Cranberry River	1	76	CR7	4.0	N38.29965	W80.51123	Circular	Corrugated metal	Cascade over riprap	Wet continuous
WV34	Bear Run	1	76	CR7	4.2	N38.30139	W80.50743	Open bottom arch	Corrugated metal	6ft dam into Cranberry R.	Wet continuous
WV35	Aldrich Branch	1	FS101	CR7	0.9	N38.34192	W80.47094	Circular	Corrugated metal	Freefall into pool	Wet continuous
WV36	Laurel Branch	1	FS76	FS232	9.4	N38.32960	W80.45465	Circle	Corrugated metal	Free fall into pool	Wet continuous
WV37	Mill Branch	1	FS76	FS232	8.7	N38.32561	W80.44374	Circle	Corrugated metal	At stream grade	Wet continuous
WV38	Upper Twin Branch	1	FS76	FS232	7.2	N38.31262	W80.42704	Circular	Corrugated metal	Freefall into pool	Wet continuous
WV39	UT to Cranberry River	1	FS76	FS232	7.5	N38.31365	W80.42885	Circular	Corrugated metal	At stream grade	Wet continuous
WV40	UT to Cranberry River	1	FS76	FS232	6.9	N38.30919	W80.42601	Circular	Corrugated metal	At stream grade	Dry
		2	FS76	FS232	6.9	N38.30919	W80.42601	Circular	Corrugated metal	At stream grade	Dry
WV41	Lick Branch	1	FS76	FS232	6.0	N38.29715	W80.42115	Pipe arch	Corrugated metal	Freefall into pool	Wet continuous
		2	FS76	FS232	6.0	N38.29715	W80.42115	Pipe arch	Corrugated metal	Cascade over riprap	Wet continuous

Crossing ID	Stream Name	Pipe #	Continous Substrate	Substrate Downstream	Substrate Upstream	Pipe Condition	Pipe Embeded	Back-watered	Fill Eroding	Poor Alignment	Breaks in Pipe	H2O Flowing Under Pipe	Inlet Bent	Inlet Blocked	% Blocked
WV01	UT to Crooked Fork	1	No	Cobble	Cobble	Good	No	No	No	No	No	Yes	No	No	0
WV02	Crooked Fork	1	No	Cobble	Cobble	Good	No	No	Yes	No	No	No	No	No	0
WV03	UT to Crooked Fork	1	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	No	0
		2	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	No	0
WV04	UT to Big Run #1	1	No	Cobble	Large gravel	Good	No	No	No	No	No	No	No	No	0
WV05	UT to Big Run #2	1	No	Cobble	Large gravel	Good	No	No	No	No	No	No	No	No	0
WV06	Teeter Camp Run	1	No	Cobble	Large gravel	Good	No	No	Yes	No	Yes	Yes	No	No	0
WV07	UT to Sams Run	1	No	Large gravel	Cobble	Good	No	No	No	No	No	No	No	No	0
WV12	Little Low Place[1]	1	Yes	Cobble	Cobble	Good	Yes	No	No	No	No	No	No	No	0
WV14	UT to N. Fk. of Deer Cr.	1	No	Cobble	Cobble	Good	No	No	No	No	No	No	Yes	No	0
WV15	North Fork of Deer Cr.	1	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	No	0
		2	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	Yes	20
		3	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	Yes	20
WV16	Elleber Run	1	No	Cobble	Cobble	Good	no	No	No	No	No	No	No	No	0
WV17	Sutton Run	1	No	Bedrock	Cobble	Good	No	No	No	No	No	No	No	yes	5
WV18	UT to Sutton Run	1	No	Cobble	Cobble	Good	No	No	No	No	No	No	Yes	No	0
WV19	UT to Sutton Run	1	No	Boulder	Cobble	Good	No	No	No	No	No	No	No	No	0
WV20	Lower Gulf Run	1	Yes	Boulder	Boulder	Fair	No	No	No	No	No	No	No	Yes	5
WV21	Whites Run	1	No	Boulder	Bedrock	Good	No	No	Yes	No	Yes	Yes	No	No	0
WV22	Smith Run	1	No	Boulder	Boulder	Fair	No	No	Yes	No	Yes	Yes	No	Yes	5
WV23	Back Run	1	No	Boulder	Cobble	Good	No	No	No	No	No	No	No	Yes	10
WV24	Elk Run	1	No	Bedrock	Cobble	Good	No	No	No	No	No	No	No	No	0
WV25	McGee Run	1	No	boulder	Cobble	Fair	No	No	No	No	No	No	No	Yes	5
WV27	UT to Cranberry River	1	No	Boulder	Boulder	Good	No	No	No	No	No	No	No	No	0
WV28	UT to Cranberry River	1	No	Boulder	Boulder	Good	No	No	No	No	No	No	No	No	0
WV30	UT to Cranberry River	1	No	Boulder	Boulder	poor	No	No	Yes	No	Yes	Yes	No	Yes	90
		2	No	Boulder	Boulder	poor	No	No	Yes	No	Yes	Yes	No	Yes	5
WV31	Hinkle Branch	1	No	Large gravel	Sand	Fair	No	No	Yes	No	No	No	No	No	0
		2	No	Large gravel	Sand	Fair	No	No	Yes	No	No	No	No	Yes	20
WV32	UT to Cranberry River	1	No	Cobble	Cobble	Fair	No	No	Yes	No	No	No	No	Yes	30
WV33	UT to Cranberry River	1	No	Large gravel	Small gravel	Good	No	No	Yes	Yes	No	No	No	No	0
WV34	Bear Run	1	No	Cobble	Cobble	Good	No	No	Yes	No	No	No	No	No	0
WV35	Aldrich Branch	1	No	Boulder	Boulder	Poor	No	No	No	No	Yes	No	No	No	0
WV36	Laurel Branch	1	No	Cobble	Cobble	Good	No	No	No	No	No	No	No	No	0
WV37	Mill Branch	1	No	Cobble	Silt	Good	No	No	No	Yes	No	No	No	No	0
WV38	Upper Twin Branch	1	No	Boulder	Boulder	Poor	No	No	No	No	Yes	No	No	No	0
WV39	UT to Cranberry River	1	No	Boulder	Boulder	Poor	No	No	No	No	No	No	No	No	0
WV40	UT to Cranberry River	1	No	Large gravel	Cobble	Good	Yes	No	No	Yes	No	No	No	Yes	45
		2	No	Large gravel	Cobble	Good	no	No	No	Yes	No	No	No	Yes	50
WV41	Lick Branch	1	No	Boulder	Boulder	Fair	No	No	No	No	No	No	No	Yes	10
		2	No	Boulder	Boulder	Fair	No	No	No	No	No	No	No	No	0

Crossing ID	Stream Name	Pipe #	Downstream Bankfull (ft)	Upstream Bankfull (ft)	Pipe Width (ft)	Pipe Height (ft)	Outlet Drop (ft)	Perch (ft)[3]	Slope (%)	Pipe Length (ft)	Slope x Length	Filter A	Filter B	Filter C
WV01	UT to Crooked Fork	1	16.5	20.0	6.0	6.7	0.2		4.1	57.7	239	Indeterminate	Impassable	Impassable
WV02	Crooked Fork	1	55.6	28.5	10.6	7.8	1.5		4.5	50.9	228	Indeterminate	Impassable	Impassable
WV03	UT to Crooked Fork	1	29.5	23.0	6.0	8.0	1.5		1.6	17.3	28	Passable	Impassable	Impassable
		2	29.5	23.0	6.0	8.0	1.5		1.4	17.3	25	Passable	Impassable	Impassable
WV04	UT to Big Run #1	1	12.3	6.0	4.0	4.0	0.5		6.7	32.2	217	Indeterminate	Impassable	Impassable
WV05	UT to Big Run #2	1	11.3	9.0	5.5	4.2	0.4		2.0	32.5	64	Indeterminate	Indeterminate	Impassable
WV06	Teeter Camp Run	1	12.0	12.0	4.0	4.0	1.7		9.0	50.2	453	Impassable	Impassable	Impassable
WV07	UT to Sams Run	1	9.0	8.5	4.8	5.0	0.7		9.2	43.0	397	Impassable	Impassable	Impassable
WV12	Little Low Place[1]	1	15.9	16.3	12.6	9.1	0.6		6.9	48.5	335	Passable	Passable	Passable
WV14	UT to N. Fk. of Deer Cr.	1	24.4	15.1	6.1	5.4	1.3		7.1	38.2	273	Impassable	Impassable	Impassable
WV15	North Fork of Deer Cr.	1	29.5	31.7	9.2	7.0	0.7		6.4	21.7	138	Indeterminate	Impassable	Impassable
		2	29.5	31.7	10.0	6.9	0.7		6.2	21.7	134	Indeterminate	Impassable	Impassable
		3	29.5	31.7	6.9	9.4	0.7		6.3	21.7	136	Indeterminate	Impassable	Impassable
WV16	Elleber Run	1	13.7	8.6	6.9	4.7	1.4		3.2	41.0	133	Indeterminate	Impassable	Impassable
WV17	Sutton Run	1	20.9	26.8	6.5	7.5		0.8	4.8	42.2	203	Indeterminate	Impassable	Impassable
WV18	UT to Sutton Run	1	14.2	8.1	4.9	5.1		2.3	10.1	37.0	374	Impassable	Impassable	Impassable
WV19	UT to Sutton Run	1	5.0	7.2	3.7	4.1	0.2		5.7	37.1	212	Indeterminate	Impassable	Impassable
WV20	Lower Gulf Run	1	16.0	18.2	5.4	5.5	0.6		3.2	30.4	96	Passable	Passable	Passable
WV21	Whites Run	1	16.0	20.5	5.0	7.2	1.8		2.6	30.9	81	Indeterminate	Impassable	Impassable
WV22	Smith Run	1	15.0	12.0	2.3	2.0	2.5		6.1	47.0	286	Impassable	Impassable	Impassable
WV23	Back Run	1	25.3	22.0	7.3	7.6	1.9		4.0	40.4	163	Indeterminate	Impassable	Impassable
WV24	Elk Run	1	15.5	16.0	9.9	6.9	3.7		1.8	32.5	59	Impassable	Impassable	Impassable
WV25	McGee Run	1	25.5	21.0	5.9	6.0	3.1		6.4	54.5	347	Impassable	Impassable	Impassable
WV27	UT to Cranberry River	1	14.0	27.0	5.5	3.8	2.2		8.1	30.2	245	Impassable	Impassable	Impassable
WV28	UT to Cranberry River	1	6.0	25.0	4.3	3.5	0.5		9.4	30.9	289	Impassable	Impassable	Impassable
WV30	UT to Cranberry River	1	23.7	19.7	2.8	2.6	0.4		8.6	30.8	264	Impassable	Impassable	Impassable
		2	23.7	19.7	3.1	3.2	0.7		7.2	30.6	219	Impassable	Impassable	Impassable
WV31	Hinkle Branch	1	16.9	10.0	4.1	3.9	0.8		3.2	31.3	100	Indeterminate	Indeterminate	Impassable
		2	16.9	10.0	4.1	4.1	0.4		2.9	31.8	93	Indeterminate	Indeterminate	Impassable
WV32	UT to Cranberry River	1	12.8	14.0	7.3	5.5	0.9		6.2	36.4	224	Indeterminate	Impassable	Impassable
WV33	UT to Cranberry River	1	8.5	11.5	3.8	4.3	0.7		2.1	25.3	52	Indeterminate	Indeterminate	Impassable
WV34	Bear Run	1	NA	19.3	12.0	8.0	5.7		0.4	37.0	15	Impassable	Impassable	Impassable
WV35	Aldrich Branch	1	12.4	6.5	2.9	3.1			-- Not Surveyed; No Upstream Fish Habitat --					
WV36	Laurel Branch	1	16.6	19.1	4.0	4.2	0.5		3.9	27.2	105	Indeterminate	Impassable	Impassable
WV37	Mill Branch	1	9.4	9.3	3.5	4.1	0.1		0.1	30.2	4	Passable	Passable	Passable
WV38	Upper Twin Branch	1	16.6	25.0	3.9	4.0	2.0		8.3	24.5	204	Impassable	Impassable	Impassable
WV39	UT to Cranberry River	1	6.0	15.8	2.0	2.2	0.0		15.1	27.0	407	Impassable	Impassable	Impassable
WV40	UT to Cranberry River	1	6.5	13.7	2.4	2.5	-0.6		4.0	31.3	126	Indeterminate	Impassable	Impassable
		2	6.5	13.7	2.4	2.6	-0.1		2.9	30.8	88	Indeterminate	Indeterminate	Indeterminate
WV41	Lick Branch	1	26.5	24.9	8.7	5.5	2.0		2.0	38.8	76	Impassable	Impassable	Impassable
		2	26.5	24.9	14.2	5.5	3.6		2.0	39.3	79	Impassable	Impassable	Impassable

Crossing ID	Stream Name	Pipe #	Site Comments
WV01	UT to Crooked Fork	1	Avg wetted width upstream 8.5ft and downstream 11ft
WV02	Crooked Fork	1	Minor erosion upstream. Avg wetted upstream 22ft, downstream 12ft
WV03	UT to Crooked Fork	1	Crossing behind gate. Downstream fish reach limited to 97 m due to private
		2	Crossing behind gate. Downstream fish reach limited to 97 m due to private
WV04	UT to Big Run #1	1	One large brook trout spotted in pool at outlet
WV05	UT to Big Run #2	1	Stone headwalls at inlet & outlet; channel splits upstream then rejoins
WV06	Teeter Camp Run	1	Paved road
WV07	UT to Sams Run	1	Behind gate with 'BEST' lock
WV12	Little Low Place[1]	1	Concrete dam at inlet; riprap and concrete headwalls
WV14	UT to N. Fk. of Deer Cr.	1	Private & confluence downstream, USFS upstream
WV15	North Fork of Deer Cr.	1	Wood box culvert; wood is charred from fire throughout
		2	Wood box culvert; wood is charred from fire throughout
		3	Wood box culvert; wood is charred from fire throughout
WV16	Elleber Run	1	Trout seen in outlet pool, barb wire 33.6m upstream
WV17	Sutton Run	1	Side rd behind gate
WV18	UT to Sutton Run	1	Side rd behind gate; not driveable due to downed trees; milepost from GIS
WV19	UT to Sutton Run	1	10 ft cascade upstream that would block fish passage
WV20	Lower Gulf Run	1	Downstream efish reach 63 m due to confluence
WV21	Whites Run	1	
WV22	Smith Run	1	Ran tape over road; downstream efish reach only ~10m due to confluence
WV23	Back Run	1	
WV24	Elk Run	1	Logs placed strategically in stream upstream
WV25	McGee Run	1	On gated road
WV27	UT to Cranberry River	1	Xing on abandoned rd. & downstream of Xing WV28; milepost est. in GIS; 10 ft vertical cascade just upstream
WV28	UT to Cranberry River	1	Stream is small and steep, questionable for fish habitat; Xing WV27 is 140m downstream
WV30	UT to Cranberry River	1	Pipe broken inside and 90% clogged from road collapsing through
		2	Pipe broken inside and 90% clogged from road collapsing through
WV31	Hinkle Branch	1	Road very muddy; recently graded.
		2	Road very muddy; recently graded.
WV32	UT to Cranberry River	1	
WV33	UT to Cranberry River	1	Fish seen upstream
WV34	Bear Run	1	No bankfull downstream due to immediate confluence with Cranberry River
WV35	Aldrich Branch	1	Channel splits upstream; not fish habitat; NOT SURVEYED
WV36	Laurel Branch	1	Outlet near confluence with Cranberry River
WV37	Mill Branch	1	Outlet near confluence with Cranberry River; campground upstream; wide and marshy upstream with lots of small fish
WV38	Upper Twin Branch	1	Outlet near confluence with Cranberry River
WV39	UT to Cranberry River	1	Steep slope upstream then flattens out a little; downstream flows into back watered pool similar to site WV38
WV40	UT to Cranberry River	1	Trib upstream with water
		2	Trib upstream with water
WV41	Lick Branch	1	Downstream runs directly into Cranberry River; upstream there are multiple large cascades
		2	Downstream runs directly into Cranberry River; upstream there are multiple large cascades

Crossing ID	Stream Name	Pipe #	Pipe Comments
WV01	UT to Crooked Fork	1	Natural boulder/bedrock apron; center of roof of pipe bowed down from weight of rd.
WV02	Crooked Fork	1	Structural plate
WV03	UT to Crooked Fork	1	Pipe 1 contains majority of flow
		2	
WV04	UT to Big Run #1	1	
WV05	UT to Big Run #2	1	1 channel had poor alignment, the other does not
WV06	Teeter Camp Run	1	Pipe made of multiple pipes put together; causing water to flow under pipe
WV07	UT to Sams Run	1	Concrete apron
WV12	Little Low Place[1]	1	Mitered pipe
WV14	UT to N. Fk. of Deer Cr.	1	Concrete retaining wall around inlet; rock wall at outlet
WV15	North Fork of Deer Cr.	1	Least amount of flow in pipe 1
		2	Medium amount of flow in pipe 2
		3	Most flow in pipe 3
WV16	Elleber Run	1	Bottom half of Pipe lined hard rubber/plastic; mitered pipe
WV17	Sutton Run	1	Freefall onto rocks followed by bedrock apron; inlet blocked with a few cobbles/boulders
WV18	UT to Sutton Run	1	Freefall onto riprap followed by bedrock apron; top of inlet bent
WV19	UT to Sutton Run	1	
WV20	Lower Gulf Run	1	
WV21	Whites Run	1	Breaks in pipe are seams between concrete pipe sections; causing water to flow under pipe
WV22	Smith Run	1	Pipe has breaks and rusted through
WV23	Back Run	1	Cinder block headwalls at inlet and outlet
WV24	Elk Run	1	Rock wall along downstream side of pipe
WV25	McGee Run	1	Riprap are natural stream boulders
WV27	UT to Cranberry River	1	
WV28	UT to Cranberry River	1	Apron is natural substrate, boulders
WV30	UT to Cranberry River	1	Middle of pipe broken and collapsed inward; blocked 90% inside
		2	
WV31	Hinkle Branch	1	Riprap acting somewhat like an apron which is a boulder
		2	
WV32	UT to Cranberry River	1	
WV33	UT to Cranberry River	1	
WV34	Bear Run	1	P7 at confluence with Cranberry River
WV35	Aldrich Branch	1	Extremely rusted with some breaks in pipe; NOT SURVEYED no fish habitat
WV36	Laurel Branch	1	
WV37	Mill Branch	1	Painted black
WV38	Upper Twin Branch	1	Pipe rusted and broken in multiple areas
WV39	UT to Cranberry River	1	Rusted with a few holes
WV40	UT to Cranberry River	1	Substrate continuous after first foot at inlet
		2	
WV41	Lick Branch	1	Concrete bottom; Most flow in pipe 1
		2	Bottom concrete